

Exploring Interspecies Sensemaking: Dog Tracking Semiotics and Multispecies Ethnography

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ABSTRACT

The domestic use of tracking technology with pets is on the rise, yet is under-researched. We investigate how tracking practices reconfigure human-dog relationships changing both humans and dogs. We question the sensemaking mechanisms by which both humans and dogs engage in context-based meaningful exchanges via the technology's mediation. We show how an indexical semiotic perspective could inform the development of interspecies technology. Finally, we discuss the methodological issues raised by doing research *with* animals and propose an interspecies semiotics which integrates animal companions and animal researchers' accounts into ethnographic observation.

Author Keywords

Tracking, dog, human, family, human-animal interaction, animal-computer interaction, semiotics, ethnography.

ACM Classification Keywords

H5.m. Information interfaces and presentation. J4. Social and behavioral sciences.

INTRODUCTION

With the popularization of location-tracking applications, researchers have investigated how tracking practices between humans can affect the behavior, relationships and lives of members in tight-knit groups such as families [3,18]. However, the use of tracking technology is rapidly extending to nonhuman family members, such as cats and dogs [9], and pet owners can now choose between a wide variety of purposely designed GPS devices (e.g., Tagg [32], GlobalPetFinder [6], SpotLight [31], Retrieva [30]). In spite of the fact that tracking pets is becoming a significant social trend, there has been very little research on this subject. In human-animal interaction research, only few studies have looked at the use of GPS devices during specific activities such as hunting [26,33]. They have shown how tracking technology affords new interactional opportunities that affect the role of both humans and dogs during the hunt.

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But how is tracking technology used in everyday life? How do tracking practices affect human and nonhuman family members? How does tracking shape their interactions and, more broadly, their relationships? Moreover, existing studies have focused on the human side of the relationship, either by exploring human experiences with and expectations of the technology [26]; or by observing the manifest interactions of humans with dogs mediated by the technology [33]. But is it possible to question the sensemaking mechanisms which may be at play on both sides of the relationship, and through which tracking technology may change both humans and dogs?

Our research investigates the social significance of technologically mediated human-animal interactions. We are interested in how tracking devices for dogs are used within domestic contexts in the everyday management of human-canine relationships and care-taking practices; we are interested in how these practices influence the behavior of and change both human and canine family members. However, since we cannot communicate with dogs in the same way that we communicate with humans, this kind of research clearly raises methodological issues to do with the interpretation of human-dog manifest interaction (similar issues arise in studies with young children and adults with communication impairments [15]). Exploring these issues is important for the development of the emerging areas of human-animal interaction [33] and animal-computer interaction [17]. In order to study technology-mediated human-animal interactions or to develop user-centered technology for animals, we need to question what these interactions and the technology that mediates them might mean for animals as well as humans. Therefore, our research questions how technology might acquire and convey meaning for both; we question how this meaning might be inferred by or communicated between the two, and how it might inform the way in which the two adapt to each other and coevolve; we also question how this *co-constructive* [9] meaning exchange could be accessed and understood by those researching the interconnections between humans, animals and technology.

We conducted a qualitative, exploratory study comprising a series of phone, face-to-face and situated interviews with 17 British households, in which adult humans used tracking technology with one or more of the household's dogs, for periods ranging from 1 week to 8 years, and with

frequencies ranging from daily to yearly. The contribution of our research is two-fold. Firstly, we analyze the social significance of tracking practices for both humans and dogs: we show how the technology affords humans new ways to interact with their dogs, as a mean to better understand and care for them; we also discuss how dogs respond to their humans' behavioral changes and to the technology itself as a meaningful artifact, adjusting their own behavior. Thus, we highlight design implications for the technology, discussing how specific features of tracking applications could further support human-dog interaction and dog-computer interaction. Secondly, we take a semiotic approach to the analysis of technology-mediated human-dog interactions, by which we refer to how meaning is produced and exchanged within those interactions: we investigate how the tracking device becomes the vehicle of a meaningful exchange, via what mechanisms the exchanged meaning might be construed by both humans and dogs, and how it might be accessed by researchers. Thus, we highlight implications for the design of research in this area: we discuss how the accounts of human participants, evaluated in relation to the accounts of canine behavioral researchers, can contribute to the ethnographer's observations by giving them access to the unique, contextual forms of interaction between individuals of human-canine groups.

BACKGROUND

The importance of keeping track

The human-dog relationship has a long history [27], yields many benefits [21], and plays an important role in society [24]. There are currently around 8 million pet dogs in the UK, with over 23% of households including at least one dog [29]. Owners are legally responsible for their dogs' welfare and behavior [4], both of which imply always keeping track of them. Indeed, not being able to keep track of one's dog may have serious repercussions.

Dogs often accompany their humans on outings or holidays, and 'walkies' are typically part of their daily routine. When outdoors, many owners favor letting their dogs off the lead, so they can properly exercise and express more natural behavior, both of which are important for their welfare and positive integration in the household. However, when off lead, dogs can be easily distracted by smells, sights or sounds, and cover long distances in short periods of time. Hence, owners have to constantly balance the benefits of giving their dogs freedom against the risks of not being able to retrieve them. When a dog wanders off, there is a risk that she might get lost, especially if she finds herself in unfamiliar territory. While microchipping makes it easier for a dog to be reunited with her family, the system relies on her being found by someone who has her interest at heart as well as access to the supporting infrastructure. An unsupervised dog might be abducted for ransom or never to be returned, with some breeds being especially at risk. In rural areas, a wandering dog might also become the target

of farmers, who have the legal right to shoot dogs on sight if they enter private land and appear to threaten livestock. In urban areas, on the other hand, she could cause or become the victim of a road accident, the consequences of which the owner would be liable for. While out of sight, a dog could also become injured and physically impaired, due to a variety of possible causes. It is within this context that, for an increasing number of dog owners, location-tracking technology becomes a tool which enables them to fulfill their social responsibility, towards both their dogs and other members of society, within daily care-taking practices.

Technology-mediated human-animal interactions

Location-tracking technology has been used with animals for a long time, for example to monitor endangered populations of wild species in conservation efforts [12] or to coordinate the team work of humans and dogs during hunting. Within these settings, Paldanius *et al.* [26] have focused on issues of system reliability and usability, considering how actual and desirable features can or could support the hunting process. With a different angle, Weilenmann and Juhlin [33] have investigated how the technology allows the hunter to interpret the dog's behavior and infer his intentions, thus influencing the interaction between the two and the role of the dog during the hunt. Beyond specific activities such as hunting, Paldanius *et al.* [26] have also looked at hypothetical uses of tracking and monitoring technology within everyday care-taking and management practices. However, while location-tracking between human family members has benefited from in-depth investigation (e.g [3,18]), the actual integration of interspecies tracking in domestic life and its effects on canine as well as human members is yet to be explored.

Within the area of user-computer interaction, researchers are starting to pay attention to the relation between humans, animals and technology and Mancini has called for the systematic development of an animal-computer interaction agenda [17]. So far, the emerging discourse includes work mainly concerned with the development and evaluation of technology for animal and human use, which benefits animals, supports human-animal interactions and fosters interspecies relationships. This work mainly focuses on interspecies interfaces (e.g., Mankoff *et al.*'s interfaces for interspecies social awareness [19], McGrath's review of species-specific interfaces [22], Lee *et al.*'s mixed reality system for tactile interaction between chickens and humans [16], Golbeck and Neustaedter's pet video chat system [7]) or entertainment (e.g., Noz and An's interactive iPad games for cats and humans [25], Hu *et al.*'s remotely controlled interactive physical games for dogs [11], Wingrave *et al.*'s canine amusement and training system [34]). In this work, evaluation with respect to the animal experience of the interaction takes two different forms: observation of the animals' behavior [16] and testimonials of their human companions [25]. However, this research does not explicitly analyze the sensemaking mechanisms which might be at

play on both sides during these interactions. The question remains as to what interpretational mechanisms might allow us to relate specific behaviors and observations to how the animal might make sense of a technological intervention and how that might affect them. Addressing this question might help us reflect on human-animal interactions, and relationships more broadly, and might help us identify or evaluate qualities that could make such interventions more relevant to animals.

The emergence of multispecies ethnography [13] has drawn attention to the need for investigating interspecies relationships, including technology-mediated relationships, and to the theoretical and methodological issues raised by such investigations. The main question that underlies this research is how to make sense of our interactions with other species. In his study of dog-human interactions, Goode [8] critiques both behaviorism and symbolic interactionism as interpretational frameworks. The first reduces interactional exchanges to a series of stimuli and reactions, as it regards any sensemaking mechanisms underpinning interaction as simply inaccessible. The second presupposes the existence of shared mental states, i.e. sensemaking processes that use symbols in the same way, which is problematic especially when dealing with animals. Goode proposes to overcome these pitfalls by taking an ethnomethodological approach to the analysis of human-dog interaction, which focuses on *manifest interaction in context*. This approach informs Weilenmann and Juhlin's in-the-wild study of dog tracking during hunting [33]. The authors do not make assumptions about the possibility that the hunting dog might have mental states, such as intentions, which the hunter might be able to interpret. They, so to speak, delegate that decision to the hunter and observe how the hunter decides based on his interpretation of the dog's movements as mediated by the tracking application. The authors point out that bodily language plays an important role in human-dog interactions and that methods chosen to study them need to capture this aspect, as ethnomethodology does. However, questions arise which this approach does not address. What are the mechanisms that underpin the non-linguistic, bodily languages on which human-dog interaction is based and which define how tracking technology mediates that interaction? Can we aspire to access those mechanisms to any useful extent and, if so, how? Furthermore, while ethnomethodology focuses on the immediate context of the interaction, that interaction takes place within a wider relational context, which may not be manifest to the researcher but which may define the interaction. Then, how could this wider relational context be accessed?

A biosemiotic approach

Communication is at the core of what it means to be alive across all organisms [2], even though the mechanisms through which communication processes take place may differ from one species to another. Without *semiosis* (i.e. the production and interpretation of signs) organisms could

not make sense of, adapt to and survive in the world. In her exploration of companion species relationships, Haraway [9] emphasizes the importance of engaging with the *material semiotics* of other species, even if we cannot fully access them, in order to better understand other animals and our relationship with them. Anthrozoologist Kohn [14] articulates this view in detail. The author proposes that, in order to understand nonhuman selves and how to interact with them, we need "*a representational system that regrounds semiosis in a way that gets beyond these sorts of dualisms [between animal bodies and human meanings] and the mixtures that often serve as their resolutions*". Recognizing that semiosis is "*always embodied in some way or another, and it is always entangled, to a greater or lesser degree, with material processes*", Kohn postulates a transspecies semiotics based on *indexicality*, one of the semiotic mechanisms in Peirce's representational system [28]. Peirce distinguishes three kinds of sign: *symbols* (e.g., words or mathematical formulas) are completely abstract, their relation to the referent being conventional; *icons* (e.g., someone's portrait or a geographical map) are more or less abstract and convention-based, their relation to the referent being established by degrees of similarity; *indices* (e.g., a footprint or a smell) are the most direct and physically grounded of all signs, their relation to the referent being established by contiguity (i.e., a footprint is directly produced by a foot). Importantly, indices are contextually established associations. Human communication uses a combination of symbols, icons and indices, but the first two are seldom used or accessed by nonhuman species. However, indexical communication is readily accessible to nonhuman species, including dogs. Thus, we investigate how indexical semiotics can support the interpretation of technology-mediated human-animal interactions.

The perspective of indexical semiotics on interspecies interaction neither precludes nor requires shared mental states (since meaning is always grounded in individual and cultural experience, shared mental states are unachievable even between humans). Instead, such a perspective recognizes that communication is always grounded in material and contextualized associations that are established over time by both humans and dogs through interaction practices. As Kohn points out, deciphering canine associations is not about attributing (our) meaning to dogs; but there is little doubt (and canine behavioral research confirms) that dogs are capable of attributing (their own) meaning. Indeed, if they were unable to interpret the world around them, they would not be able to adapt to and survive in it. The question is whether this meaning is accessible to humans and the probable answer is that, at least to an extent, it is. Another's meaning does not have to be (and it never is anyway) accessed in its entirety in order for communication to be functional, to which many *co-constructive* [9] human-dog relationships are witness. Thus, if we are to understand how animals are affected by technology-mediated interactions with humans and how we

can design technology that supports such interactions for both sides of the relationship, we need to try and interpret the material and contextualized associations by which both human and animal might each attribute or express (their own) meaning and through which process they both adapt. However, since these associations are established over time through interaction practices between individuals in a relationship, how is an exogenous researcher to access them? In this research we explore the extent to which the semiotic work of the dogs' human companions, evaluated in relation to the semiotic work of canine behavioral researchers, may have a role to play when it comes to interpreting a dog's semiotic processes.



Figure 1. Retrieva collar with ViewRanger software

STUDY

To explore the issues discussed above, we conducted a qualitative, exploratory study of dog tracking in domestic settings. The study comprised interviews and home visits with 17 households distributed across the UK, where one or more human members used location-tracking technology with one or more canine members. The interviews took place over the phone initially and were followed by home visits and field interviews with selected households.

Methodology and approach

Technology

All participants had used Retrieva (Fig.1), a commercially-available, live-tracking collar featuring quad-band modem, SIRFIII GPS chipset and 433mHz RF transceiver. The waterproof collar has optimized sky-view antenna placement to maximize performance in difficult terrain, and a recharging interval of 5-7 days. The system can be used with the topographic mapping software ViewRanger or other location-based applications, on any smart phone that supports live tracking, iPad, laptop or desktop computer. During live tracking the position of both tracker and tracked, including speed and direction of the tracked, are displayed on a map. The device can record up to 7,000 locations and a positioning history can be visualized. The system enables the set-up of virtual fences around a specific location and alerts the owner if the dog crosses the boundaries. The collar is adjustable and has an anti-theft

mechanism, which alerts pre-set phone numbers and email addresses if opened or tampered with.

Participants

Participants included 20 human adult users and 23 canine wearers. The lifestyle and daily environment of human participants varied from rural to urban and they were aged between 30s and 70s. The lifestyle of their dogs varied accordingly, they were aged between 1 and 10, and had been wearing the tracker for periods ranging from 1 week to 8 years, with usage varying from occasional to daily.

Interviews

Both phone and field interviews were loosely structured in order to allow the exploration of emerging themes. During field interviews the researcher interacted with both humans and dogs. The researcher aimed at eliciting information and observations about:

- Household's composition, members' background and activities (e.g., gender, age, family role and occupation of humans; gender, age, breed and main activities of dogs);
- Relationship between humans and their dogs (e.g., how humans described the relationship with the dogs, how much time they spent with them, what activities and routines they shared);
- Tracking motivations and practices (e.g., how long the dogs had been wearing the tracker for; why humans had started using the technology, when and how they used it, what they thought might be the risks of not using it);
- Humans' assessment of the direct or indirect reactions of their dogs to the tracker (e.g., what changes humans had experienced in the dogs' behavior, or in their interactions with them; how they construed the associations between tracking practices and the dogs' behavior).

Findings

We focus our presentation of the findings on the following aspects:

- Human participants' reasons for tracking their dogs;
- Use of tracking technology within human-dog daily practices;
- Humans' sensemaking of the information mediated by the tracking technology;
- Humans' interpretation of how the dogs made sense of and reacted to the tracking device.

Participants are referred to by household and role within it (e.g., husband in HH7).

Why humans wanted to track their dogs

Participants mainly reported tracking their dogs in order to protect and care for them, describing them as their children and companions. A couple in HH17, who lived in a suburban area, had been using the tracker with their beagle on a daily basis, including on holiday, for the previous six months. One of them commented: "[our dog] *is like our*

child...sleeps on the bed with us, has breakfast and dinner at the same time as us, sits on the couch with us in the evenings...he comes almost always on holiday with us". Participants wanted to be reassured their dogs were safe while allowing them some of the freedom they thought the dogs needed. "...he has no road sense, so we want to track him as soon as he's gone" (HH17).

While for those living in urban areas the main concern was car accidents, those living in rural areas were more commonly worried that their dogs might get shot. The participant from HH7 lived on a farm with her husband and their two lurchers, both of whom had worn the tracker regularly when around the farm, for five months: "*They go quite a distance...and game keepers have the right to shoot on sight any dog crossing their land...once my uncle brought [one of them] back... 'keep her away, if I find her there again you know I have the right to shoot her'...so we got the trackers*". The participant was also concerned that her dogs might be abducted, as were a number of other participants, regardless of where they lived, especially if their dogs were pure-bred. A professional couple in HH4, who lived in the suburbs with their Jack Russell terrier, commented: "*There has been a lot of dog theft in this area...especially his breed, they are very popular*".

Being able to take their dogs along during trips was important to many participants and they wanted to be able to do that safely, without fearing that the dogs might get lost in unfamiliar surroundings. A young couple in HH3 lived on a farm with their three German shepherds, a bitch and her sons, all of whom were regularly wearing the tracker. The couple recalled how distressing it had been for them when the bitch had gone missing during a trip the previous year, after which incident they started using the tracker: "*Until you actually lose your dog, you don't realize how distressing it is... you are completely powerless*" (husband), "*We were very scared, well I was a mess...it was horrible...I'll never forget it*" (wife). Other participants reported similarly distressing experiences, which had prompted them to start using the tracker. The couple in HH2, both dog trainers, lived in a suburban area with their two Shetland sheep dogs and four Border collies. Ten months earlier, during a trip to take part in an agility competition, one of the males ran away: "*He was frightened by a car alarm...there were five hundred people outside the caravan who came to help me find him, asking where do we look...I had no idea what to tell them*".

But a dog could also go missing in familiar surroundings, for example, because of injury or other accidents. The participant in HH15, who lived in a semi-rural area with her husband, youngest son and three dogs, had started using the tracker with her Border terrier, following an episode six weeks earlier: "*She went missing for a week...it was horrible...she had got stuck down a ditch and couldn't come home*". The fear that one's dog might be in trouble while out of sight was not uncommon: "*As they are terriers,*

they run off to hunt...they come back eventually, but you don't know if they are in trouble...last year my wife was four and a half hours in the woods waiting for them to come back". Following that episode, the couple in HH12, who spent half their time cruising the country in their canal boat, fitted both their Border terriers with trackers, which the dogs always wore for going out and on the boat.

Finally, one participant in HH13, a search and rescue dog handler had tried the tracker with his Border collie for curiosity more than concern, using it during his dog's training sessions and occasionally on call-out. Of all the households, he was the only one to use the tracker similarly to hunters, to coordinate a specific type of human-dog cooperation activity.

How humans used the tracker in daily human-dog practices
Participants relied on the *remote vision* [33] afforded by the tracker and interpreted the information this provided to infer the dogs' situations and possibly anticipate their next actions, in order to respond as they deemed appropriate. For the participant in HH13, the use of the tracking technology mainly supported his search and rescue activity, allowing him to monitor his collie's coverage of the terrain and assess the thoroughness of her work. The technology was particularly valuable to him in conditions of impaired visibility: "*When searching an area in the dark the tracker lets me see what area [she] has covered*".

Other participants tended to make a more pervasive use of the tracker, which was consistent with the pervasive nature of their concerns. Typically those living in rural areas would check on their free-roaming dogs to pinpoint on the map exactly where they were and ensure that they were not about to stray in neighboring private fields or, if they had, intercept them before they got into trouble: "*I can find them before they get shot*" (HH7). Participants would also use the tracker to monitor the vitality of their dog. The couple in HH1 lived with their seven Huskies in a semi-rural area and during their long walks in the copse liked letting their dogs off lead in turns. The husband pointed out: "*If their position doesn't change for a while, you know they may be injured and need rescuing*". On the other hand, the participant in HH8, who lived on an isolated farm with her husband and their Rhodesian Ridgebacks, only used the tracker to monitor one of them when she had to leave her home: "*She is too trusting of strangers...I keep checking to reassure myself [that she is still there]*".

The tracker also afforded participants the possibility of implementing new tactics for keeping up with their dogs. With fast moving dogs, for example, they could use the dogs' position, speed and direction of movement to try and predict the dogs' trajectory and get ahead of them. The participant in HH16, who lived in the country with two Springer Spaniels, reported: "*If they run off, they can go very fast...at least I can see where [she] is...it gives me an idea of the direction in which she's heading...I get the land*

rover out and try to get ahead of her, or catch up with her with my whistle and loud voice". Furthermore, participants whose dogs tended to run away when called now had a new advantage on them. The participant in HH6, who lived on a farm with his wife and Cocker spaniel, commented: "I don't call him [anymore] but look him up instead, so he can't run off". Participants also reported that being able to track their dogs afforded them the opportunity to give them timely feedback on their behavior: "Because now we can go and find her, we can tell her off for having run away...before we couldn't, as she would have just come back and we would have to praise her" (HH15). Moreover, the technology had allowed participants to gain new insights into their dogs' behaviors and habits when left to their own devices, hence accessing parts of their dogs' lives that would have otherwise been inaccessible to them. The couple in HH3 commented: "Sometimes we like to see on the computer where they've gone when we've let them out at night".

How humans made sense of the tracking information

Tracking applications can be seen as media based on *remote indexicality*. They employ a combination of sign types: map drawings are icons that mirror the image of the represented territory; names of places and other graphic signs are symbols that represent political features of the territory. However, the central signification mechanism is based on indexicality: although the object that represents the dog might be an icon (e.g., a picture) or a symbol (e.g., a dot), its movements on the map are directly, albeit remotely, produced by the movements of the dog in the physical world.

On the backdrop of the territorial representation provided by the map, the participants' understanding of the tracker's basic functionality allowed them to easily identify the position and movement of their dogs in the physical space. Of course, at this basic level all participants made sense of the same information in the same way. However, the participants' interpretation of the motion patterns which they observed on the map was entirely context-based. That is, participants interpreted those motion patterns based on their knowledge of their individual dogs and of the territory, making specific inferences about the dogs' situation, activities and even social dynamics. For example, we have already seen how the participant in HH13 used the tracker to coordinate with his search and rescue Border collie. Much like the hunters in Weilenmann and Juhlin's study, he knew exactly what the dog was doing and used the motion patterns produced by her on the map to assess her activity on the ground.

We have also seen that the participants in HH3 liked to use the tracker to check what their German shepherds had been up to the previous night. In particular, they used the motion patterns produced by the dogs to make sense of their nocturnal activity and evolving social dynamics: "You can go back and look where they've been and it's actually been very interesting to see just how far they've gone, but they

stick together in a pack and you can see they've normally gone somewhere in a straight line, they've obviously chased after something, you can see where they've been..." (husband), "It was nice to see they all stick together, though, also I wanted to see the leader, find out the one who would take it [the leading role], I thought it was [the mother], which it was at first, but then [one of the sons] took over...we think he is trying to be the top dog, the pack leader, first they were following [her] about, then they were following [him] about" (wife).

If the motion patterns of the dog's symbol on the map did not match their expectations, some participants inferred that something might be wrong. For example, we have seen how the participant in HH8 relied on that symbol not to move outside the boundaries of her house where she wanted her dog to remain safe and how, on the other hand, the participant in HH1 did not expect the symbol to be stationary.

Participants relied on their contextual knowledge of the territory to assess whether, given a particular location or trajectory, their dogs were in a dangerous situation. For example, as a result of what he had learnt about their dogs' roaming habits, the participant in HH12 admitted that he and his wife had restricted the freedom previously given to their dogs: "We are much more careful not to let them run off as with the tracker we could see that they go to dangerous places, where they could get shot or run over...so we now give them less freedom".

Some participants were worried that their ability to make appropriate inferences about their dogs' immediate circumstances was limited by the fact that they might not have enough contextual information and that the tracker did not provide that for them. For example, the participant in HH10 worried that, based on his contextual knowledge of a territory, he might be able to infer that his dog was potentially in danger, but the tracker did not tell him what was actually happening to his dog: "If I see that he is in a dangerous place I am still very worried until I physically find him". Similarly the participant in HH1 did not know if a stationary dot on the map actually meant injury. Later we discuss ways in which the technology could address these limitations and offer dog owners better support here by providing a more context-enriched signification system.

How humans construed the dogs' reactions to the tracker

Some participants reported that the use of the tracker had influenced their dogs' behavior and that the dogs had associated the device with specific categories of events. The participant in HH2, the dog trainer, commented about his collie: "We made a big fuss of the collar, so when we put it on him he thinks something good is going to happen". Although only one dog wore the tracking collar, it appeared that the other dogs in the household also associated the collar with the imminence of an exciting event: "They also know that something good is going to happen so they are

happy too". According to the participant, the collar was a "comfort blanket" for the dog, who had associated it with a reassured and thus reassuring state in his human: "When we go somewhere new and put the collar on him he is more relaxed because I am more relaxed". It is known that dogs respond to their humans' emotional displays and the participant's observations are backed by research showing that, presumably because of their coevolution with humans, dogs are able to read human facial expressions and body language. When asked how he could tell his dog responded to wearing the collar, he answered with a practical demonstration, while pointing the attention of the researcher to the dog's body language: the human picks up the tracking collar; he calls the dog; the dog goes to him; the human stands still, holding the collar in front of him like a crown; the dog sits very close facing the human, with his nose straight up towards the collar now suspended above his head, vigorously wagging his tale and staring at the collar without taking his glance off it until the human slips the collar onto his neck; then the dog gets up and walks towards the door surrounded by the other dogs. In the experience of the participant this reaction was significant and specifically elicited by the tracking collar.

Similarly, others reported that their dogs had learnt to associate the collar with 'going places'. The participant in HH9, hypothesized that his German shepherd might have associated the collar with being let off the leash, hence her excitement at the appearance of the device: "She knows she is going somewhere when we put it on...we let her have more space because of it...she may have associated the collar with that so is very excited about it". Likewise, the participant in HH5, commented about her cross-breed rescue dog: "She associated the collar with the runs...the click [of the lock] of the collar on the neck meant fun time". On the other hand, the participant in HH8, who only used the collar to monitor her dog when at home alone, commented: "She knows she is going to stay home when I put the collar on".

In these cases, according to the participants' observations, the dogs had presumably connected the device to the events that occurred whenever the collar was put on them within the specific context of particular human-dog interaction practices. The fact that the dogs presumably had no concept of the tracker's functionality would not have prevented them from attributing it meaning by establishing an indexical association with a pleasant (going places off leash) or unpleasant (staying home alone) experience. What the participant of HH5 described as the trigger of her dog's association, the click of the collar's lock onto her neck, is in fact at the basis of something known as click training [5], where trainers teach dogs to associate clicks (made with a small mechanical device) with particular events or actions, and then use the clicks to recall or elicit those later on. Hence, it is plausible that what the participant had observed was a spontaneous occurrence of click training with regards to a meaning of the collar that was relevant to the dog.

In general, participants demonstrated a keen *ethnographic disposition* in analyzing the apparent effects of the tracker on their dogs, supporting their analysis with background information. Some reported effects in their dogs' social interactions resulting from the fact that, thanks to the use of tracking technology, their humans were willing to give them freedom. The participant in HH1 commented about his Huskies: "They are more friendly with other dogs, because they are able to interact socially...unlike dogs that are always on a lead". He supported his statement by explaining that Huskies are gregarious and pack-oriented, which makes appropriate social interaction with other dogs particularly important. This is in fact a known issue in canine behavior and it is hypothesized that guide dogs tend to be the victims of dog attacks because their harness prevents them from exhibiting proper greeting behavior, which may be interpreted as a challenge by upcoming dogs. When asked how he had come to the conclusion that walking off lead made his dogs more sociable, he responded that it was by contrast with the Huskies of long-term acquaintances of his, who never let their own dogs off lead for fear that they will disappear.

Participants also reported that, having afforded a change in their humans' behavior, the use of tracking technology had also produced a change in the interaction between the dogs and their humans. For example, the participant in HH6 reported that his Spaniel "became more clever in being elusive...before I got the collar he would disappear in the woods until it was time for his dinner...[then] when he first had it [the tracker] I would find him and he would just surrender...but then he would watch out for me and run off again as soon as he saw me...so it became a bit of a game". According to his account, the dog had adjusted his escaping tactics in response to a change in the chasing tactics of his human, who in turn became a more careful chaser. On the other hand, the participant in HH5 explained how, since wearing the tracker, her dog would come back to her more frequently during walks. She attributed the behavior to the fact that she was no longer calling the dog back when the dog disappeared: "Because I could see where she was [I would not call her]...she couldn't hear me...I'd better go and see where mum is, so she would come back...check where I was...she would come and find me". When asked how she had made that deduction, she explained: "I do a lot of reading about dog behavior...this trainer said stop calling your dog and they will come and find you...so because I had the tracker and could see her, I tried and it worked". Although these accounts are anecdotal and provide personal interpretations, they are nevertheless carefully articulated and often supported by background knowledge. They demonstrate a perspective which is indigenous to individual human-dog relationships and highlight the way in which interactional dynamics and the meaning that might mediate them on both sides are fundamentally context-dependent. This context-dependency

means that in order to access such dynamics an indigenous perspective plays an important role.

DISCUSSION

Significance of dog tracking in a multispecies society

Our findings show how important being able to track their dogs was to the participants and how the technology afforded them the ability to do so. The participants' tracking practices changed their interaction with the dogs by enabling them to understand, protect and care for them more effectively. The use of tracking devices for pets is sometimes looked at with irony, e.g. as a multimillion-dollar business opportunity at the expenses of over-protective 'helicopter pet parents' [10]. However, we found that there are objective reasons why such technology has a role to play in the daily management of human-canine relationships. Unlike humans, dogs cannot make a phone call if they fall in a ditch, they cannot explain where they come from or ask for directions if they get lost, and the law does not grant them the legal protection enjoyed by humans if they trespass prohibited territory or find themselves in the trajectory of a car. These are serious concerns for dog owners and tracking technology affords these people new means of fulfilling what Mancini *et al.* [18] term *family contract*, that is, one's "*set of explicit or implicit expectations that define the relationship between two individuals in a wider social context*". The participant from HH17 clearly expressed his sense of personal responsibility towards someone he regarded as his child: "...if I knew that the technology was there and I hadn't used it and something happened, I could never forgive myself...at least I'm doing all I can to protect him". Tracking technology enabled him to fill the gap between the need to honor the unwritten contract with a nonhuman family member and the lack of protection relative to their status in human society.

However, by giving owners the *power of remote vision*, tracking technology further shifts the human-canine relationship's balance. Unlike children [3], dogs cannot emancipate themselves from the status to which they are relegated by a human society that struggles to recognize and make room for their autonomy and *self-ownership*. While research shows that tracking human family members often raises ethical concerns, such as privacy issues and social tensions [18], these did not emerge in our study. But could we construe the behavior of a dog who runs off when the owner pops up from behind a tree as a desire for privacy [23], which is violated by the tracking technology? Could we construe the behavior of a dog who suddenly starts frequently checking on their owner during walks as a sign of anxiety, which the technology has shifted from the owner to the dog? If so, how could we articulate the boundaries between protection and *respect* [9] in our research on technology-mediated human-animal interactions? Such research has the potential to redefine the way in which we understand our relationships with other species and to contribute to the development of a more inclusive society.

But in order to fulfill this potential researchers need to explore these ethical issues with genuine *curiosity* [9], no matter how challenging or ironic they may appear.

Richer indexical semiosis for interspecies interaction

We have seen how both humans and, according to them, their dogs engaged in a process of *context-based indexical semiosis* mediated, at different levels, by the technology. At one level, humans used the indexical patterns of their dogs' movements to interpret their situations and activities based on the knowledge of their individual dogs and the territory. However, they were aware of the medium's limitations and of the ambiguities that context-based inference may present. For example, they might see from the tracker that their dog was stationary and, since that was unlike their dog, guess that something might be wrong. Or they might realize that their dog was in a potentially dangerous place, but did not know how likely or imminent the danger could be. In other words, sometimes the tracker just did not provide users with the contextual information they needed to assess their dog's circumstances. To address these limitations, designers could explore the possibility of adding new functionalities to tracking technology in order to enrich the indexical semiosis afforded by such applications. For example, future tracking harnesses might feature learning algorithms and sensors measuring canine biometric parameters (e.g., pulse, temperature, respiration). Based on those measurements, on habitual movement patterns and on the amount of time that a dog has been stationary, the symbol representing her on the map could change or the system could alert the owner. To help owners make more accurate inferences about the dog's immediate environment and any potential threats to her, tracking applications could be provided with geotagging features allowing users to post comments about locations for the benefit of other dog owners (e.g., history of dog thefts, farmers likely to shoot, hidden ditches).

Like human participants, dogs appeared to engage with the tracker as a meaningful object, but they did so at the physical level of the artifact, the collar itself. According to their owners, the dogs interpreted the collar or the sound emitted by the lock as a signal of an imminent outing, not any ordinary outing, but a more exciting one, as their body language signaled to their owners. As animal behavioral research finds [20], animals use signals all the time: these can be very direct *cues* (e.g., limping indicates injury), or *ritualized signals* that have become somewhat decontextualized (e.g., in some birds' flight intension movements seem to have been ritualized into courtship displays). Because their purpose is to communicate, *signals* are more conspicuous to facilitate interpretation. Moreover, embodiment and physical grounding seem to always be an important aspect and the physical qualities of sound are also important in vocalizations (e.g., cats and dogs may distinguish and enjoy the moving patterns in a cartoon [25] or video without recognizing what those represent; or they may recognize sufficiently high fidelity sound and be

puzzled by its disembodiment [7]). These aspects of animal communication should be taken into account when developing technology for interacting with animals or for animals to interact with. This could mean, for example, using physical devices whose conspicuously different features are used to signal different things (e.g., the collar could emit distinctly different sounds to signal that an outing will be a short stroll in the local park or an exciting adventure in a new place). Or it could mean experimenting with high quality acoustic features in physical devices (e.g., tracking collars could have speakers to allow owners to reassure their dog with their voice while they walk or await rescue). At a time when computer interactions are increasingly ubiquitous and embodied, developing technology for animals is more possible than it has ever been, provided the perspective is appropriate. The dogs in our study responded to the device (e.g., with excitement) or to the adaptations that the device afforded their humans (e.g., stalking quietly) by adapting in turn (e.g., becoming more watchful), which drove further change in their humans (e.g., becoming more careful stalkers). Humans and dogs are interconnected in a cycle of semiotic exchange and coevolution, of *becoming-with* [8], which characterizes the interaction between living organisms. The issue is what kind of coevolution we want our technology to foster and how the semiotic processes underpinning such coevolution can be best supported.

Accessing context through indigenous accounts

We discussed how the indexical associations underpinning human-animal interaction are established over time within the context of an individual relationship. This means that accessing the meaningful exchanges that develop between the members of the relationship may require an inner perspective. We have seen how participants showed an analytical perspective on their interspecies relationships, and perhaps it is not by chance that Goode's insightful analysis of human-dog interactions is auto-ethnographic [8]. Because dogs' human companions participate in the protracted interaction through which indexical associations are established on both sides, they are in a position to either indexically demonstrate those associations (by triggering them deliberately: "*Let me show you what he does when I do this...*") or, so to speak, translate them in symbolic terms (i.e., natural language: "*You know, when I do this he always does that...*"). Thus dogs' human companions can offer the benefit of a viewpoint which is *indigenous* [33] to the relationship.

The question then arises as to how such accounts can be, so to speak, validated to ensure that they are appropriately insightful and therefore useful. We propose that these accounts should be unpacked by the ethnographer during their interaction with human research participants. Human companions should be able to explain how they construe the associations they observed, and their interpretation process should be analyzed by the ethnographer in light of

current *research accounts* of canine behavior. Like the dogs' human companions, animal behavioral researchers themselves engage with the indexical semiotics of the animals whom they aim to understand, and they too *become-with* them [9]. The resulting semiotic work produces accounts which can help the ethnographer evaluate the companions' accounts. Indeed, our human participants often grounded their observations on specific aspects of canine behavior. Although, even well-grounded insights may only crudely approximate the meaning of canine indexical associations, they may be good enough to be useful when developing or evaluating technology that is intended to support either human-animal interactions or animal-computer interactions. We propose that these companions' accounts, with animal researchers' accounts, can significantly contribute to ethnographic observation and, thus, to the ethnographer's own *integrative semiotic work*. This approach could be developed to study the connection between humans, animals and technology, but could have wider implications and applications [15,17].

CONCLUSIONS

We have investigated how tracking technology affords humans new ways of relating with their canine family members, and how it mediates a semiotic exchange through which humans and dogs coevolve. We have questioned the semiotic mechanisms underpinning technology-mediated human-dog interactions and analyzed the indexical associations by which signs and artifacts acquire meaning in the context of interactional practices between individuals in interspecies relationships. We have discussed how this contextualized meaning might not be manifest to those who are exogenous to the relationship and how, by offering the researcher an indigenous perspective, the accounts of dogs' human companions might provide an understanding not accessible by observation alone. We have suggested that these accounts could be evaluated in relation to the semiotic work of animal behavioral researchers and have proposed an *integrative interspecies semiotic approach* to studying the relation between humans, animals and technology.

Finally, could such interspecies semiotics be accused of anthropomorphizing animals? Cognitive ethologist Bekoff argues that "*we more often make the opposite mistake: we prefer to discount what is right before our eyes and consistently underestimate what animals know, do, think, and feel.*" [1]. Perhaps, then, following Darwin's view that differences between species are a matter of degrees not substance, indexical semiosis could be thought of as a common denominator of interspecies exchanges at the origin of multispecies coevolution.

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